DOCUMENT RESUME

ED 233 879 SE 042 786

TITLE	Estimating Aquatic Insect Populations. Introduction to Sampling.
INSTITUTION	Chihuahuan Desert Research Inst., Alpine, TX.
PUB DATE	82
NOTE	21p.
AVAILABLE FROM	Chihuahuan Desert Research Institute, Education Dept., Box 1334, Alpine, TX 79831 (single copy, $0.40; class set of 30, $10.00).
PUB TYPE	Guides - Classroom Use - Materials (For Learner) (051)
EDRS PRICE	MF01 Plus Postage. PC Not Available from EDRS.
DESCRIPTORS	*Animals; Biology; *Entomology; Estimation (Mathematics); Field Studies; *Laboratory Procedures; *Sampling; Science Education; Science Experiments; Secondary Education; *Secondary School Science; *Wildlife
IDENTIFIERS	*Mark Capture Technique

ABSTRACT

This booklet introduces high school and junior high school students to the major groups of aquatic insects and to population sampling techniques. Chapter 1 consists of a short field guide which can be used to identify five separate orders of aquatic insects: odonata (dragonflies and damselflies); ephemeroptera (mayflies); diptera (true flies); coleoptera (beetles); and hemiptera (true bugs). In addition, members of the coleoptera and hemiptera can be keyed to family. Pertinent illustrations are included. Chapter 2 includes a discussion of and procedures for the mark-capture technique, a method that biologists use to estimate the size of a wild population. Although other methods can be used, the mark-capture works particularly well in estimating the population of aquatic insects in a single, small body of water on a given day. In addition, the concepts of randomness, ratio, and proportion are stressed in the chapter. Team and class data sheets for insect population sampling are included. (JN)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED233879

Introduction to Sampling

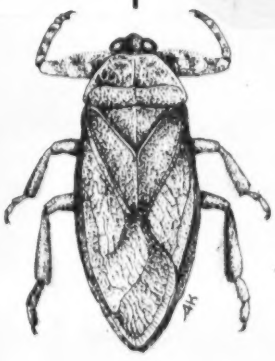
Estimating Aquatic Insect Populations

U.S. DEPARTMENT OF EDUCATION
NATIONAL INSTITUTE OF EDUCATION
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

✓ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official NIE position or policy.



"PERMISSION TO REPRODUCE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY

Alan Brenner

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

SE042786

Chihuahuan Desert Research Institute

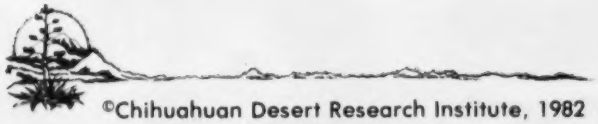
Introduction to Sampling

Estimating Aquatic Insect Populations

Acknowledgements:

The Chihuahuan Desert Research Institute Education Department wishes to thank Dr. Jim V. Richerson, Sul Ross State University, for his invaluable advice and encouragement.

Drawings by Alec Knight and Alan Brenner.



©Chihuahuan Desert Research Institute, 1982

P. O. Box 1334
Alpine TX 79830
915-837-2475

chapter 1

Aquatic Insect Communities

Insects are the dominant life forms on this planet. We usually think of ourselves as the most important creatures on earth. But in terms of ecological success, numbers of species and sheer numbers of individuals, insects have us beat.

This booklet will introduce you to some interesting groups of insects that may have escaped your notice—the aquatics. Further, you will learn about an important technique that biologists use when they want to study wild populations.

The word "aquatic" refers to water. When biologists speak of "aquatic" environments, they usually mean fresh-water environments; salt-water environments are called "marine" environments. Very few insects live in marine environments. In North America, there are about 10,000 species of insects that are aquatic at one or more stages of their life histories.

Biologists find aquatic communities to be particularly interesting because they are good places to learn about how organisms interact. Cattle tanks, small ponds and even mud puddles are tiny, self-contained habitats where the mechanisms of life can be studied on a small scale.

There are three important mechanisms operating in every community:

- energy flow
- nutrient cycles
- population regulators

The source of all the energy flowing throughout a community can be traced to the sun. The energy from sunlight is converted into usable form by plants. Plants are at the bottom of a community's "food chain." The next link in the food chain is plant-eating animals. Plant eaters become prey for predators, which are in turn preyed upon by still higher predators. The food chain not only distributes energy throughout the community, it is also important in distributing vital nutrients. The availability of food is one of the main factors regulating the size of a population. But many other factors affect population levels, like temperature or the presence or absence of a key predator.

By learning how these mechanisms operate in a small community, like a cattle tank, we can better understand how these mechanisms operate

in large communities. For example, a researcher could introduce additional predator species into a cattle tank and then monitor changes in prey populations. Such changes can be expressed mathematically. These mathematical expressions might help us predict how deer populations will change in response to increased predation by hunters.

The organisms we will study are members of a group of animals known as arthropods (which in Greek means "joint-footed"). The arthropods are divided up into classes. Insects, spiders, centipedes and lobsters are representatives of separate classes within the arthropod group. A class is in turn divided into orders, and orders into families.

Below is a short field guide which you can use to identify five separate orders of aquatic insects. In the case of two of these orders, you can use the guide to identify separate families. We will not try to identify aquatics below the family level. If you are interested in identifying separate genera within a family, or separate species within a genus, you will need a detailed field guide.

I. ORDER ODONATA (DRAGONFLIES AND DAMSELFLIES): Adult dragonflies and damselflies are familiar to everyone. They are commonly found around streams and ponds, flying through the air to catch their prey. Obviously, the adults are not aquatic. The young, however, are completely aquatic and breathe by means of gills. The young are called "nymphs." (Nymphs are immature insects that somewhat resemble adults. You can clearly see wing buds on more mature nymphs.) One structure possessed by nymphs, but not by adults, is an extension of the jaw. This extension is normally folded under the nymph's head. When small animals like insects, fish or tadpoles pass within reach, the extension snaps forward, grabs the prey and draws it back toward the mouth. The picture of the dragonfly nymph shows the jaw extended. Dragonfly and damselfly nymphs can be distinguished by the gills. In the damselfly, the gills are the three leaf-like structures attached to the end of the body. Odonata nymphs look fierce, but they are harmless and easily handled. The scale (⊢———⊣) shows the average size of the insect.

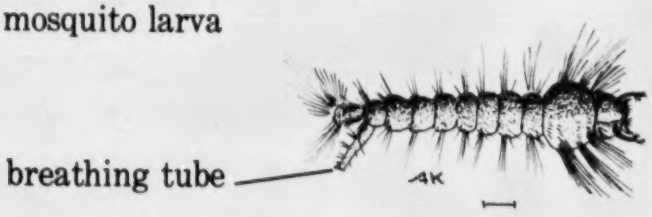
damselfly nymph

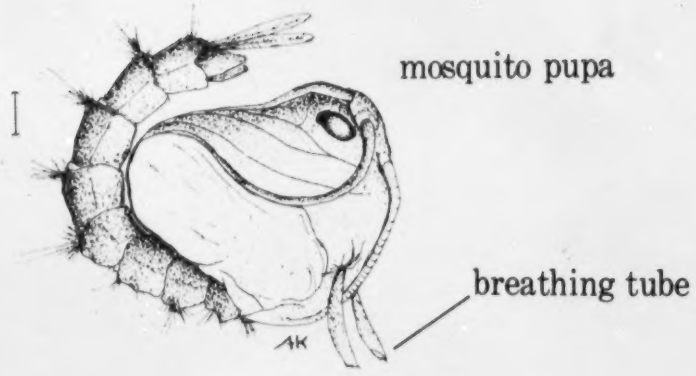
II. ORDER EPHEMEROPTERA (MAYFLIES): You may have seen large swarms of adult mayflies gathering near street lights on warm summer evenings. Adults mate and lay eggs within two days, then die. The nymphs live for up to a year as aquatic gill breathers. You can recognize them by the three long tails extending from the end of the body. Mayfly nymphs feed on plant material and are present in great numbers. They are extremely important in aquatic communities because they are a main source of food for predatory insects and fish. If you find only a few mayfly nymphs in your dip net, you may be sampling a polluted stream.

mayfly nymph

III. ORDER DIPTERA (TRUE FLIES): The most important and most common aquatics among the true flies are young mosquitoes. A young mosquito is called a larva. (A larva always looks completely different from an adult.) They live in water, breathing by means of a tube at the rear of the body. The pupa—a more advanced stage—is also aquatic. The pupa breathes through a tube near the head. Mosquito larvae and pupae eat plant material and are themselves eaten by predatory aquatics.

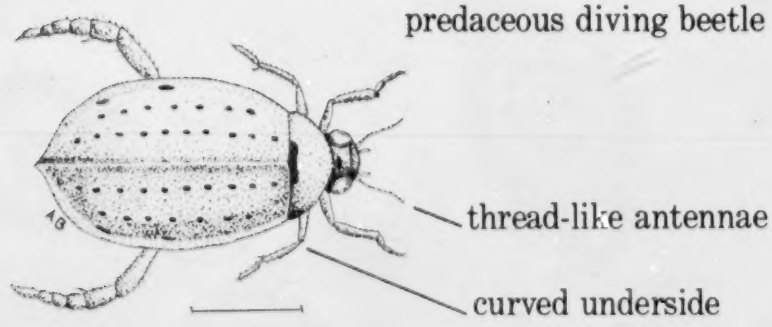
mosquito larva



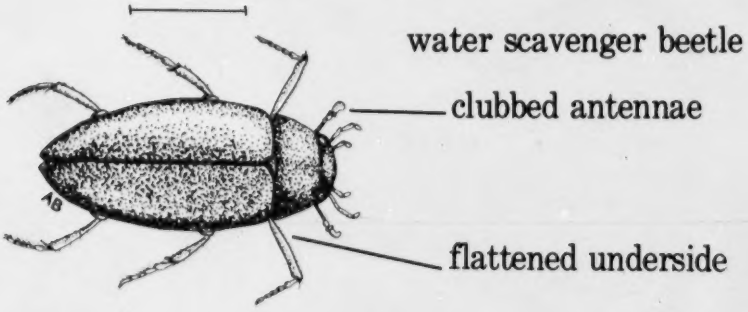


IV. ORDER COLEOPTERA (BEETLES): This is the largest order of insects in the world, with around a quarter of a million species. Only a few of the species are aquatic, but they will be very numerous in your dip net. Beetles are easily recognized by the hard shell formed by the front wings, which protect the back of the insect. Adult aquatic beetles must surface to breathe. They develop from larvae that are also surface breathers. Larvae must stay in the body of water in which they hatch, but adults fly very well and may migrate from place to place, seeking more favorable living conditions. Some aquatic beetles are brightly colored. They have pinching mouth parts but are not strong enough to cause harm to people.

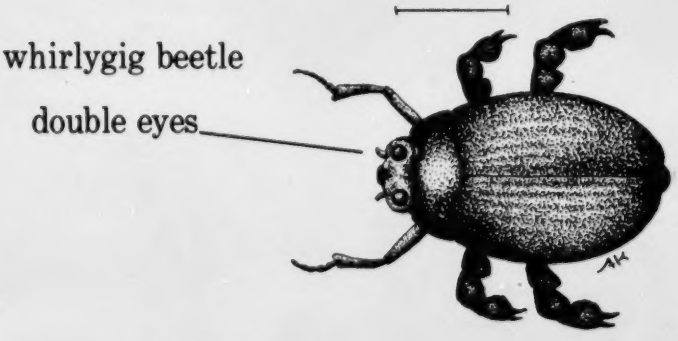
A . FAMILY DYTISCIDAE (PREDACEOUS DIVING BEETLES): As the name suggests, these beetles prey upon other animals. The back legs move in unison when swimming. Predacous diving beetles can be recognized by their thread-like antennae and their curved underside.



B. FAMILY HYDROPHILIDAE (WATER SCAVENGER BEETLES): Water scavenger beetles can be confused with predaceous diving beetles. Note, however, that water scavenger beetles have clubbed antennae and flattened undersides. The hind legs move alternately when swimming. These insects are usually blackish in color. Tiny bristles on the underside hold a thin film of air, which the insect breathes while under water. The film of air must be replenished by periodic trips to the surface. Water scavenger beetles eat living and decaying plant material.



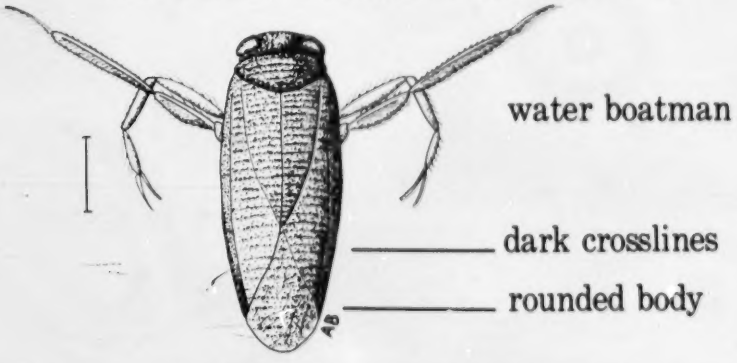
C. FAMILY GYRINIDAE (WHIRLYGIG BEETLES): These shiny black beetles are found in colonies. They glide in circles on the surface of the water. Whirlygig beetles are good divers, too. They move quickly and are difficult to net. If you manage to catch one, look closely at the head. You will see two pairs of eyes, a lower set for seeing under water and an upper set for seeing above. Whirlygigs are predatory.



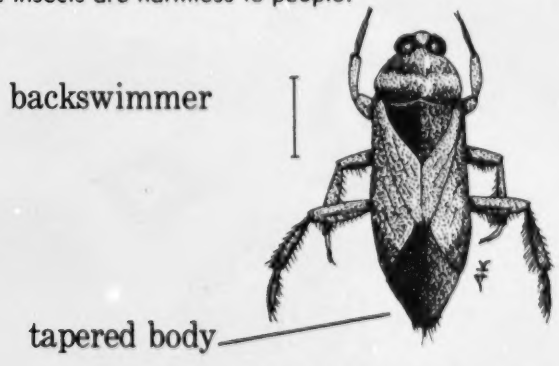
V. ORDER HEMIPTERA (TRUE BUGS): True bugs may be identified by the structure of their front wings. The base of the wing is leathery;

the tips of the wings are transparent. Most aquatic bugs are predators. They have piercing, beak-like mouth parts that inject digestive juices into their prey. Some bugs can give you a very painful bite. Be sure to handle any unfamiliar bug with forceps. Nymphs and adults are both surface breathers. The adults may migrate.

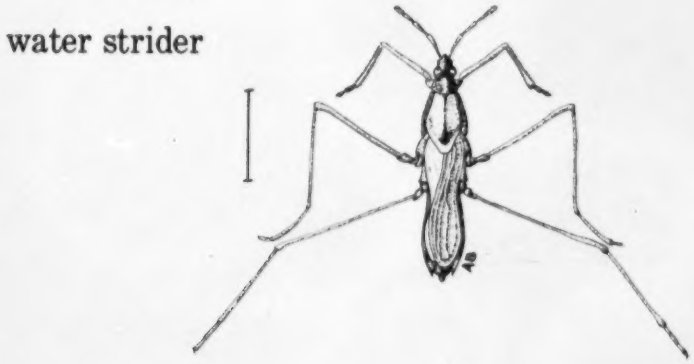
A. FAMILY CORIXIDAE (WATER BOATMEN): Water boatmen use their hind legs like tiny oars. Note that the end of the body is rounded and that there are dark crosslines on the back. Water boatmen are not strong enough to pierce the skin on your fingers and can, therefore, be handled without harm.



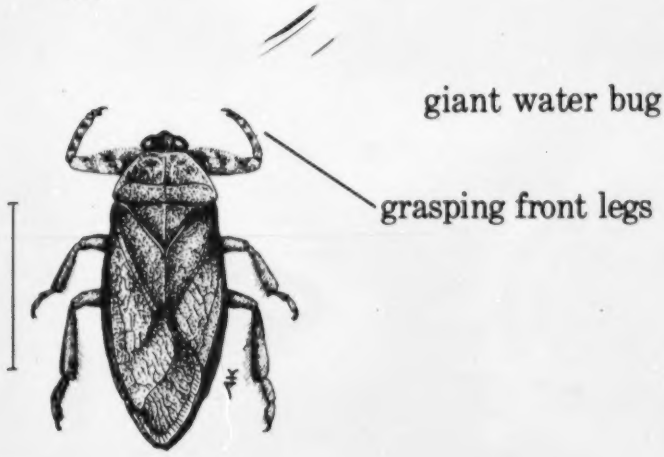
B. FAMILY NOTONECTIDAE (BACKSWIMMERS): These insects move in the water with the same motion as water boatmen—with one important difference: they always swim on their backs. They will be very common in your dip net. Once out of the water, where you cannot see them swimming, they may be hard to tell from water boatmen. Note that the end of a backswimmer's body is tapered, unlike that of a water boatman. These insects are harmless to people.



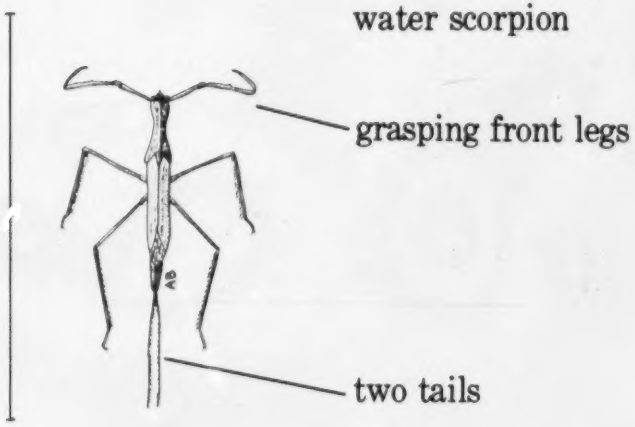
C. FAMILY GERRIDAE (WATER STRIDERS): These are probably the most familiar aquatic insects. You will see them skimming the surface of the water, grouped together in colonies. Harmless.



D. FAMILY BELOSTOMATIDAE (GIANT WATER BUGS): Watch out! These insects can inflict a severe bite. Note that they have strong, grasping front legs with which they pull their prey—or your finger—toward their piercing beak. Use forceps to handle them. Giant water bugs measure up to two inches in length, which makes them the largest aquatic insect in North America. (Most of the specimens you will find will be under an inch long). They cling to submerged vegetation, waiting for prey to pass near.



E. FAMILY NEPIDAE (WATER SCORPIONS): Like giant water bugs, water scorpions can deliver a painful bite. But they are so sluggish that they can be handled with little risk. Simply hold them between thumb and forefinger just behind the rear legs. They are easily recognized by their elongated bodies and double tails.



You need very little equipment to study aquatic insects. The best dip net to use is one with a stirrup-shaped opening. This allows the opening of the net to rest flush against the bed of the stream as you drag it through the water. Thus, you are more likely to capture bottom dwellers. A shallow basin with a light-colored bottom is handy for holding the contents of your net for study. Aluminum pie plates and enamelled wash pans work well. Don't forget to bring along a pair of forceps.

If you want to preserve aquatic insects for further study, store them in a 70% solution of ethyl alcohol. Methyl and isopropyl alcohol (the kind you are likely to find at your local super market) can be used, but specimens turn dark after a few days. A few drops of glycerine added to the solution will make it possible to salvage a specimen in the event that the alcohol accidentaly evaporates. Ethyl alcohol and glycerine are available from biological supply houses.

Many insects are active for only short periods of time during the year. But aquatic insects can be studied in their natural habitat year around. If you live in a warm climate, aquatics are active in all seasons. In cold climates, the pace of life slows considerably during the winter, but you may still be able to find a few aquatics swimming around, even under a layer of ice.

chapter 2

Mark-Recapture Population Studies

The mark-recapture technique is one method that biologists use to estimate the size of a wild population. There are many other methods used, but mark-recapture works particularly well with aquatic insects. Suppose, for example, you wanted to study the effects of pollution on a body of water. Let's say that a factory has begun dumping waste into a stream. You would want to know if the polluting chemicals are causing insect populations to change. If the factory were to stop dumping waste a year later, you would want to know how quickly the stream populations return to normal.

One way to answer questions like these is to count every insect in the entire stream. Obviously, this is impossible. You would first have to select certain portions of the stream to examine. You might, for instance select one quiet pool for each mile of the stream's length. But you still cannot count every species of insect in each study site. There might be hundreds of separate species. Therefore, you could select a few key species to examine—say, one predator species, like giant water bugs, and one prey species, like mayfly larvae. But even when you narrow down your research to a few study sites and a few species, you cannot simply start netting insects and counting them. In each study site, there might be thousands of mayfly larvae of a given species, and you could never know when you had captured them all. Your best bet is to estimate the population by counting a few individuals. Finally, you cannot make a separate population estimate every day for a whole year. Instead, you might return to your study sites every few months.

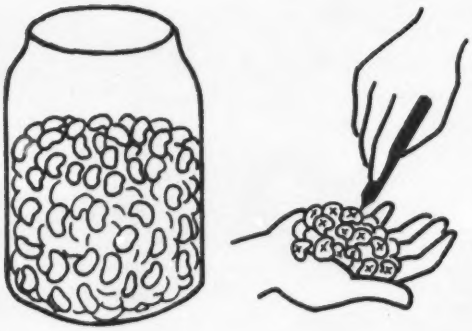
The process whereby scientists narrow down the scope of their investigation is known as sampling. We assume that by examining a few parts of a system, we can draw conclusions about the whole system. When we select just one predator and just one prey species to examine, we assume that the results will indicate what is happening with all the predator and prey species. When we estimate the total population by counting just a few individuals, we assume that our results are fairly accurate. And when we return to our sampling site every few months, we assume that our results will indicate general trends over a full year.

You may not be ready to undertake an elaborate research program like the one described above, but you can use the mark-recapture technique to estimate the population of one group of insects in a single small body of water on a given day. The principle of the mark-recapture techni-

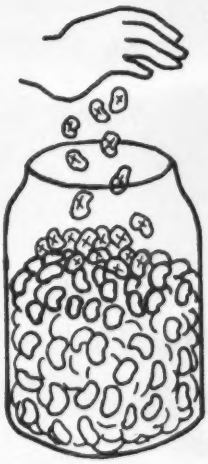
que is easily demonstrated in the classroom. All you need to accomplish this is a large glass jar or other suitable container, a bag of large white beans from the grocery store and a felt-tip pen.

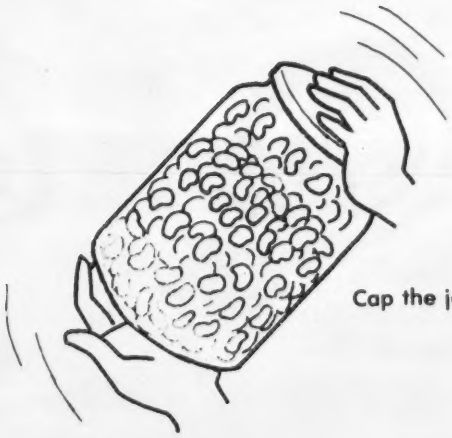
The jar represents the body of water you will sample, and the beans represent a population of insects. Your hand represents the dip net.

Scoop out handfulls of beans until you have 50. Using your felt tip, mark each bean with a large *X*.



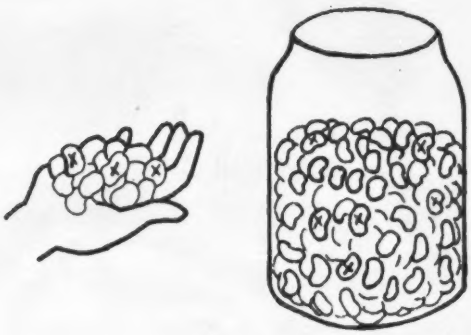
Return the marked beans to the jar.





Cap the jar and shake vigorously.

The marked beans are now evenly distributed among the unmarked beans. Take a sample of the beans in the jar. Reach in and scoop up a large handful.



Count the number of beans in your sample. If you did not get at least 30 beans in your sample, reach in and scoop another handful. Let's say that your sample size just happens to equal 30. Next, count the number of marked beans that turned up in the sample. If a bean is marked, we know that it has been "recaptured." Let's suppose that the number of recaptured beans equals 5.

The fraction of marked beans in our sample is 5/30, which reduces down to 1/6. If the fraction of marked beans in the sample is 1 out of 6, we can assume that the fraction of marked beans in the entire population is also about 1 out of 6. We can now set up a simple equation that will give us an estimate of the total number of beans in the jar.

$$\frac{\text{number of marked beans}}{\text{population of beans in jar}} = \frac{\text{number of recaptured beans}}{\text{number of beans in sample}}$$

Here is the equation in short form.

$$\frac{m}{p} = \frac{r}{s}$$

We know the values for m, r and s, but not for p. Plugging in the known values, we get

$$\frac{50}{p} = \frac{5}{30}$$

This equation can be solved using elementary algebra.

$$\frac{m}{p} = \frac{r}{s}$$

$$\frac{50}{p} = \frac{5}{30}$$

divide 50 by 5 to find the number in the box

$$\frac{50 = 5 \times \boxed{10}}{p = 30 \times \square}$$

the number in the top and bottom boxes must be the same

$$\frac{50 = 5 \times \boxed{10}}{p = 30 \times \boxed{10}}$$

$$p = 30 \times \boxed{10}$$

multiply 30 by 10 to find p

$$p = \boxed{300}$$

The number of beans in the jar is about 300. We say "about" because when we sample, our results can never be perfectly accurate. The accuracy of our result will depend on whether our sample was truly random. If we had failed to shake up the jar, we might recapture too many

or too few marked beans. If we had tried consciously to grab marked beans (or to avoid grabbing marked beans) while sampling, we would have gotten a similarly distorted result.

We can increase the reliability of our result by marking more beans—say, 100—or taking a bigger sample—say, three handfulls. But the more you try to increase reliability, the more time it takes to get your result. Marking 100 beans and taking a three-handful sample would require almost as much time as counting all the beans in the jar. Your time as a researcher is valuable. A good scientist learns how much accuracy to sacrifice in order to save time.

Here are a couple of problems to practice on. The answers appear at the end of this booklet.

Problem 1: A class wanted to estimate the number of beans in a jar. They removed 45 beans and marked them. Then they returned the beans to the jar and shook vigorously. A sample of 61 beans was taken from the jar. The students found 3 recaptured beans in the sample. What was the estimated number of beans in the jar?

$$\frac{m}{p} = \frac{r}{s}$$

$$\frac{45}{p} = \frac{3}{61}$$

$$45 = 3 \times \square$$

$$p = 61 \times \square$$

$$p = \square$$

Problem 2: Some biologists wanted to estimate the number of backswimmers in a pond. They netted 50

backswimmers, marked each with a dab of nail polish and released them back into the stream. The biologists waited several hours for the insects to redistribute themselves throughout the pond, then took a sample. In a sample of 66, they found they had recaptured 8. What was the estimated number of backswimmers in the pond?

$$\frac{m}{p} = \frac{r}{s}$$

$$\frac{50}{p} = \frac{8}{66}$$

$$\frac{50}{p} = \frac{8 \times \square}{66 \times \square}$$

$$p = \square$$

Are you ready to try estimating a population of aquatic insects, yourself? Sampling proceeds most efficiently if researchers work in teams. Assign each class member to a team of four researchers.

The equipment that each team will need is fairly easy to assemble. Your science teacher should be able to supply you with a dip net, a pair of forceps and a large jar. From home, bring some nail polish. Nail polish is the substance you will use to tag the insects you are studying. However, the brush which is normally used to apply the polish is unsuitable for marking insects. With a large pair of scissors, cut off about half of the plastic stem of the applicator and discard the brush. Drive a straight pin into the end of the stem. With the head of the pin, you can place a neat dab of color on an insect. Light, reflective shades of polish work best.

If the wether is warm and you don't mind getting wet, wear tennis shoes and shorts. If the weather is cool, you may be able to sample from the bank of a stream or from the wall of a cattle tank. Otherwise, obtain one pair of waders or high boots for each team of four.

Find a suitable sampling site near your school. Assign each team to

work a specific section of the sampling site. For example, if you have decided to sample a circular cattle tank, divide the tank up into wedge-shaped sections. If you are sampling a pond, assign each team a certain section of the bank. If you are sampling a stream, find a quiet stretch of backwater for each team.

Before you begin the procedure, take a few trial scoops with your net. Note which orders and families are present. Together, the class should decide on the organism to be sampled. This decision should be based upon the abundance of the organism at the sampling site and the suitability of the organism for mark-recapture exercises.

Small, soft bodied insects are difficult to mark with nail polish. This eliminates mayfly nymphs and mosquito larvae as candidates. Fast moving insects like water striders and whirlygig beetles may be too difficult to capture in sufficient numbers. Water scavenger beetles and predaceous diving beetles work well for mark-recapture exercises if you are familiar enough with the two families to tell them apart. Their shell-like wings are water repellent and dry instantly in the air, making it easy to apply nail polish. True bugs, especially the backswimmers and water boatmen are excellent for these purposes. They are large enough to handle easily and require only a few moments in the air to dry sufficiently for nail polish to be applied. Dragonfly and damselfly larvae are large, slow moving and easy to recognize. Their bodies are somewhat soft and may take longer to dry.

When the class has decided upon the organism to be sampled, the exercise begins. Each team moves to the assigned position and repeatedly drags their nets through the water, along the bottom and among standing vegatation. As one researcher brings up netful after netful, a second researcher sorts through the contents, discarding rubbish and unwanted insects. When a specimen of the insect group in question is spotted, it should be captured by the second researcher and secured gently but firmly between the thumbs and forefingers of both hands. Meanwhile, the third researcher stands ready with the bottle of nail polish and applies a dab of color to the head of the insect, to the horny plate just behind the head or (in the case of beetles) to one of the wings. The fourth researcher records the number of insects which have been marked.

Be careful that you do not apply so much polish as to smother the insect or interfere with the action of the wings. When the tag has been applied, blow on the insect for a second or two to set the polish. Then, place it in a jar which has been filled with water to a depth of a few inches. Capture and mark at least 30—preferably about 50—insects, then dump the contents of the jar back into the habitat. Then, it's time for a break. Enjoy a sack lunch, or take a hike for an hour. During this time, the insects you have captured and marked are redistributing themselves throughout the community.

When you return to the sampling site, begin the recapture phase of the exercise. One researcher handles the net, sampling randomly. The second and third researchers pick through the contents of the net, capturing specimens of the insect in question and placing the specimens in the jar. The fourth researcher records the total number of insects in the sample and the number of recaptured (marked) insects. Keep working until you have collected a sample of at least 30 insects *and* have also collected at least 3 marked insects. The larger the sample, the more accurate will be your results. When you have finished sampling, return all the insects in the jar to the habitat unless you plan to take them back to class for study.

While in the field, each team should enter its data on a team data sheet that looks something like the one pictured at the end of this chapter.

When you and your fellow researchers have returned to the classroom, pool the data from each team on a single class data sheet (see the example pictured at the end of the chapter). The equation on the data sheet should be solved for *p*, which is the estimate of the population.

If you enjoyed doing field research on aquatic insects, you may want to try a more ambitious project: sample a population of insects at regular intervals over the course of a whole year. Determine whether there are seasonal fluctuations in population levels.

A good way to learn more about aquatic insects is to capture living specimens of several predator and prey species and set them up in an aquarium in your classroom. Incorporate into your aquarium some plant material and bottom rubbish from the original habitat. Be sure to aerate the aquarium with an air pump. Observe first hand how energy and nutrients flow throughout the community—that is, observe who eats what, who eats whom. Install an aquarium heater, and raise the temperature. Observe which populations increase and which decline.

An excellent, but somewhat technical, guide to aquatic insects is *How to Know the Aquatic Insects* by Dennis M. Lehmkuhl (The Picture Key Nature Series, Wm. C. Brown Company, 1979). Also, the publishers of the booklet you are reading, the Chihuahuan Desert Research Institute of Alpine, Texas, can supply your class with a teaching kit containing preserved specimens of some of the more common aquatic insect groups.

Your questions and comments concerning this exercise are welcome. Write the Education Director, CDRI, P. O. Box 1334, Alpine, TX. We'd like to hear from you.

Answers to problems

Problem 1: p = approximately 915.

Problem 2: p = approximately 412.5.

TEAM DATA SHEET

Team Members _____

_____

_____

_____

Insect sampled _____

Location of sample site _____

_____

Number of insects marked (m)	Number of insects in sample (s)	Number of insects recaptured (r)

Name _____

CLASS DATA SHEET

Insect sampled _____

Location of sample site _____

_____

	Number of insects marked (m)	Number of insects in sample (s)	Number of insects recaptured (r)
Team 1			
Team 2			
Team 3			
Team 4			
Team 5			
TOTAL			

$$\frac{m}{p} = \frac{r}{s}$$

$$\frac{\square}{p} = \frac{\square}{\square}$$

$$\frac{\square = \square \times \square}{p = \square \times \square}$$

$$p = \square$$